1.0 Introduction

In recent years, there has been increasing interest in the ability of travel demand models to estimate travel not only for the average weekday, but for different periods within the day. In the past, travel demand models were mainly used for such purposes as determining the size or capacity of major new transportation investments or estimating travel demand and revenues for transportation projects such as new transit lines. Nowadays, models are required to be analysis tools for a much broader range of issues and transportation policy and project alternatives, including transportation demand management (TDM) policies, transportation systems management projects, and air quality analysis. These issues often require much more detailed analysis than in the large scale models of the past, not only spatially, but temporally as well.

This report provides documentation on methods used in U.S. urban areas to handle the issue of time-of-day in their travel demand models. Commonly used practices are described, and the most innovative methods used by metropolitan planning organizations and states are documented in detail. A range of time-of-day related issues are addressed, including disaggregation of daily travel estimates, peak spreading, and emerging approaches. The "Terminology" section of this report (Section 6.0) lists acronyms and technical terms with their definitions.

■ 1.1 Background

In travel modeling, the simplest form of trip assignment is to assign a single peak period or daily vehicle trip table to the highway network. In the past, this procedure has provided adequate information for the development of long-range transportation plans, identification of required new facilities, and planning for major investments in alternative modes of travel.

These traditional uses of travel data from daily assignments are still valid objectives of travel demand modeling and work reasonably well for general planning purposes, especially if there is relatively little congestion in the planning region. However, increasing traffic congestion together with recent environmental and economic considerations have resulted in increased emphasis on the management of traffic systems and the development of capabilities to forecast congestion levels throughout the day.

All regions experience some peaking of travel demand in the use of the transportation system. As an example of this, Figure 1.1 shows the percent of daily trips by start time based on two household travel surveys in Colorado Springs, Colorado and Cleveland, Ohio. These two metropolitan areas are quite different in size, transportation system, and economic activity. While these cities are quite different in character, they exhibit

Figure 1.1

strikingly similar patterns in tripmaking by time-of-day. Both cities are characterized by the morning peak period and the afternoon peak "plateau," along with a noon-time "mini-peak." While the total magnitude of trip making and transportation supply is substantially different for the two cities, both cities are similar in that they would strain the transportation systems during the peak periods.

The time at which travel occurs and, more specifically travel peaking intensity and duration are critical to the estimation of a number of important travel performance measures, including speeds, congestion, and emissions. Yet peaking and time of travel are included in the traditional travel model in highly approximate ways, typically by developing peaking or time-of-day factors from observed data and assuming the same patterns will persist in the future. More robust, behavioral representations of the time-of-day of travel have only been recently introduced into the travel demand modeling practice, especially in large urban areas with significant levels of traffic congestion.

1.2 Need for Time-of-Day Modeling Procedures

During the past two decades, there has been a changing emphasis in transportation planning, resulting in travel demand models needing the capability of analyzing travel conditions at different times of day. A major focus is now being placed on traffic congestion and air quality issues as related to transportation planning. Typically, the transportation planner is asked to identify highway system deficiencies, develop plans for traffic management, and estimate traffic growth and air quality impacts related to new developments. Some of the emerging requirements are summarized below:

- Vehicle Emissions and Air Quality Analysis. The Federal Clean Air Act Amendments (CAAA) and State Clean Air Acts have established stringent air quality analysis standards. Analysis of vehicle emissions depends on several inputs from travel demand models including traffic volumes, vehicle speeds, traffic compositions, vehicle-miles and hours of travel by facility type, by vehicle type, by hour of the day, and by vehicle starting mode (hot starts and cold starts). Furthermore, accurate forecasts of vehicle volumes and speeds by time-of-day are required due to the wide variation of emissions levels as vehicle speeds change.

- Congestion Management Programs. The Intermodal Surface Transportation Efficiency Act (ISTEA), and State Congestion Management Programs have also established stringent analytical standards. These requirements have created many specific analysis needs to be addressed using travel demand models including the ability to accurately forecast travel speed, congestion, delay, and time-of-day travel. As traffic management strategies on existing transportation facilities replace capital improvements that increase capacity, travel demand models must capture the effect that these traffic management strategies have on time-of-day travel.

- Identification of Highway System Problems. Many roadway problems stem from peak period congestion. In many urban areas, simply factoring daily volumes to a single peak hour is not sufficient to accurately quantify peak travel demands, since the severity of the peaking and the congestion vary throughout the urban area and over time. As travel demand increases and exceeds the transportation supply, failing to account for route diversions caused by congestion results in a false picture of the highway system.

- Transit Analysis. While travel demand models for large urban areas have long had transit analysis capabilities, they have generally been rather imprecise tools to measure the amount of transit travel. Mode choice models generally are applied at the daily level (or to daily trips by purpose), meaning the variations in transit service availability throughout the day are ignored. Transit assignments are usually all-or-nothing assignments of a daily transit trip table with time-of-day factors sometimes applied at the link level. This severely limits the capability of travel demand models to forecast transit patronage, especially in cases where transit ridership may be changing significantly, for alternatives that may significantly alter transit usage trends, or for alternatives that significantly change the ratio of base to peak period supply.

- Analysis of Transportation Demand Management (TDM) Alternatives. In many areas, TDM alternatives are being considered as ways to alleviate peak traffic congestion, reduce dependence on single-occupant auto travel, and address air quality and other environmental concerns associated with auto travel. Often these measures are aimed at peak period travelers, especially home-to-work commuters. Types of TDM policies that require peak travel analysis capabilities include parking charges, congestion pricing, transit subsidies, variable work hours, and telecommuting.

- Time-of-Day Travel Choices. As peak period congestion increases, many travelers wishing to avoid the added delay have some choice when it comes to the time they choose to make trips. This is evidenced by "peak spreading" that is occurring in many urban areas. As congestion increases, it can be expected that more travelers will choose to move departure times away from peak periods. The ability to model this type of behavior is critical when analyzing alternatives that may significantly change the times and costs of traveling during peak periods.

- Analysis of Intelligent Transportation Systems (ITS). ITS is currently under deployment in many urban areas as a lower-cost alternative to capital improvements. ITS includes advanced traffic management systems, advanced traveler information systems, commercial vehicle operations, and advanced public transportation systems. Analysis of ITS systems requires improved modeling capabilities to accurately estimate changes in operational characteristics such as traffic volumes, speed, delay, and queuing by time-of-day.